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USE OF ABBREVIATIONS

1. The JOURNAL recognizes the utility and convenience of some non-standard abbreviations for chemical substances, particularly in equations, tables, or figures requiring several unwieldy terms in close or repeated context. The JOURNAL therefore will accept a *limited* use of abbreviations of specific meaning as defined below. However, in order that scientific writing be comprehensible to the reader, clarity and unambiguity of expression must remain prime considerations.

2. Title and summaries, which are most often translated into foreign languages, should be free of abbreviations, and abbreviations should be minimized in the introductory sections.

3. In the remainder of the manuscript, abbreviations may be used in the text sparingly and only if advantage to the reader results. Chemical equations, which traditionally depend upon abbreviations, may utilize an abbreviation for a term that appears in full in the neighboring text. This latter procedure is also permissible in summaries, when necessary to avoid excessively cumbrous expressions, as in equations or polymer structures. Such essential abbreviations in summaries are to be defined therein when first used; *e.g.* flavin adenine dinucleotide (FAD).

4. Where space limitations require an abbreviated name or symbol, as in a column heading in a table or on a figure or photograph, it is preferred that this be drawn from the "accepted" list given below or be formulated in accordance with the principles of this section.

5. Authors may consult the JOURNAL'S Committee on Nomenclature and Abbreviations in advance of submission of a manuscript, or independently, for advice or suggestions on difficult problems of abbreviations or nomenclature. This Committee is in close contact with the IUPAC Committee whose Tentative Rules have been reprinted in this Journal **237**, 1381–1387 (1962).

6. *Formulation of Abbreviations*—Abbreviations other than those listed or defined below should be in accordance with the following principles:

The number of these introduced per article should be limited (3 or 4); none should be introduced except where repeated use is required (see above). Three letters are considered optimum in length. The formation of words by these letters or duplication of an accepted abbreviation is to be avoided. Where a number of derivatives, salts, or addition compounds may be formed, the root or common basic structure should be the one abbreviated so that appendages may be hyphenated to it (*e.g.* AMP-sulfate, acyl-AMP). It is suggested that abbreviated names be hyphenated throughout, even where the full name is not (*e.g.* glucose-6-P, but glucose 6-phosphate). Accepted symbols for elements or radicals are recommended where applicable (*e.g.* glycero-P for glycerophosphate, P-glycerate for phosphoglycerate). Structural analogues of the pyridine nucleotide coenzymes may be abbreviated according to the principles that led to the abbreviations NAD and NADP for the coenzymes themselves; *e.g.* 3-acetylpyridine adenine dinucleotide could be denoted as AcPyAD (see editorial in the *Journal*, **237**, 979, 1962).

7. *Names Ordinarily Not To Be Abbreviated*—Names of enzymes (except when named in terms of an abbreviation, *e.g.* glucose-6-P dehydrogenase, ATPase, but glucose 6-phosphatase; RNase, DNase), pyridoxal, pyridoxamine, deoxypyridoxine, thiamine, cocarboxylase, pantothenate, folic acid, pteroylglutamate, trichloroacetic acid, perchloric acid, the tricarboxylic acid cycle and members thereof should not be abbreviated, nor should groups easily represented by chemical symbols, such as hydroxymethyl ($-CH_2OH$) or tetrahydro ($-H_4$). In referring to folic acid derivatives it is recommended that the names "tetrahydrofolic acid" or "tetrahydrofolate" be written out in full, unless repeated many times in a paper, in which case the abbreviation "folate-H_4" may be used; as also "folate-H_2" for dihydrofolate. Derivatives can similarly be referred to, *e.g.* "5 (or 10)-hydroxymethylfolate-H_4" or "5 (or 10)-CH_2OH-folate-H_4."

8. *Accepted Abbreviations*—The abbreviations in the list given below may be used without definition. Other abbreviations should be defined in a single footnote at the point of introduction of the first one. Accepted abbreviations are as follows (*cf. Biochem. J.* **71**, 1 (1962)):

NMN	nicotinamide mononucleotide
NAD (or NAD^+), NADH	nicotinamide adenine dinucleotide and its reduced form
NADP (or $NADP^+$), NADPH	Nicotinamide adenine dinucleotide phosphate and its reduced form
(The older abbreviations, DPN, DPNH, TPN, TPNH, are still acceptable, but the two systems of notation should not be mixed.)	
FAD, $FADH_2$	flavin adenine dinucleotide and its reduced form
GSH, GSSG	glutathione and its oxidized form
CoA, acyl-CoA	coenzyme A and its acyl derivatives (*e.g.* acetyl, etc.)
AMP, GMP, IMP, UMP, CMP	the 5′-phosphates of ribosyl adenine, guanine, hypoxanthine, uracil, cytosine
2′-AMP, 3′-AMP (5′-AMP), etc.	the 2′-, 3′-, (and 5′-, where needed for contrast) phosphates of the nucleoside
ADP, etc.	the 5′(pyro-)diphosphates of adenosine, etc.
ATP, etc.	the 5′(pyro)-triphosphates of adenosine, etc.
deoxy-AMP(dAMP, dGMP, dIMP, dUMP, dCMP, dTMP)	the 5′-phosphates of 2′-deoxyribosyl adenine, etc.
RNA, DNA	ribonucleic acid, deoxyribonucleic acid
RNase, DNase	ribonuclease, deoxyribonuclease
UDP-glucose, UDP-galactose, etc.	uridine diphosphate glucose, galactose, etc.
P_i, PP_i	orthophosphate and pyrophosphate
Tris	tris(hydroxymethyl)aminomethane
EDTA	ethylenediaminetetraacetate

Phosphorylated derivatives may be depicted as phosphate derivatives of the parent compounds with P- or -P representing phosphate, as in glucose-6-P, P-glycerate, glycerol-P, P-enolpyruvate, PP-ribose-P (ribosylpyrophosphate 5-phosphate).

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For Diagrammatic Representation of Polymers or Sequences—(*a*) For the amino acid residues in polypeptides, the residue with the free alpha-amino group (if one is present) to be understood to be at the left of the sequences as written (*Ann. Rev. Biochem.*, **16**, 224 (1947)):

Gly, Ala, Val, Leu, Ileu	glycyl, alanyl, valyl, leucyl, isoleucyl,
Pro, Phe, CySH, CyS, Met, Try	prolyl, phenylalanyl, cysteinyl, half-cystyl, methionyl, tryptophanyl
Arg, His, Lys	arginyl, histidyl, lysyl
Asp, Glu,	aspartyl, glutamyl,
$GluNH_2$, $AspNH_2$	glutaminyl, asparaginyl
Ser, Thr, Tyr,	seryl, threonyl, tyrosyl,
Hypro, Hylys	hydroxyprolyl, hydroxylysyl

These symbols should be separated from each other by short dashes (*e.g.* Gly–Val–Asp–Ser). Groups of residues of unknown sequence may be enclosed in parentheses and separated by commas. These abbreviations should be used only for amino acid residues in peptide linkage, never for the free amino acids, the names of which should be written out in full. In the text the terminal residues in a peptide chain are to be referred to as the NH_2-terminal and the COOH-terminal residues.

(*b*) For the polysaccharides (*J. Chem. Soc.*, **1952**, 5121; *Chem. Eng. News*, **31**, 1776 (1953)):

Glc, Fru, Gal, Rib, deoxy-Rib (dRib), etc.	glucose, fructose, galactose, ribose, deoxyribose, etc.

(These abbreviations are to be used only for derivatives or polymers of the monosaccharides, not for the free monosaccharides themselves, the names of which should be written out in full.) When it is necessary to indicate furanose, pyranose, etc., the letter *f* or *p*, following the saccharide abbreviation, may be used. Thus, Rib*f* for ribofuranose. To indicate an aldonic acid the suffix A, for acid, may be used. Thus, GlcA for gluconic acid. For uronic acids, the suffix UA may be used. Thus, GalUA for galacturonic acid. To indicate a 2-amino-2-deoxysaccharide, the suffix N is added to the parent saccharide symbol, and an *N*-acetyl derivative is shown by NAc. Thus, GalN for galactosamine, GalNAc for *N*-acetylgalactosamine. Configuration symbols (L-, D-) may be used as prefixes. Each residue is separated from the next by a hyphen; thus, UDP-GalNAc.

(*c*) For polynucleotides of specific structure, the letter p to the left of the nucleoside initial indicating a 5′-phosphate; the letter p to the right, a 3′-phosphate:* Thus, for polyribonucleotides (A, G, etc., representing the nucleosides of adenine, guanine, etc.):

pApG	5′-*O*-phosphoryl-adenylyl-(3′-5′)-guanosine, or guanylyl-(5′-3′)-adenosine 5′-phosphate
ApGp	adenylyl-(3′-5′)-guanosine 3′-phosphate
ApG-cyclic-p	adenylyl-(3′-5′)-guanosine 2′, 3′-phosphate

for polydeoxyribonucleotides:

d-pApGpT	5′-*O*-phosphoryl-deoxyadenylyl-(3′-5′)-deoxyguanylyl- (3′-5′)-deoxythymidine, or deoxythymidylyl-(5′-3′)-deoxyguanylyl - (5′-3′) - deoxyadenosine 5′-phosphate.

Where bases and nucleosides must be independently abbreviated, as in a hybrid polymer or in a minimal space (as on a chromatogram or in a column heading), the terms Ade, Gua, etc., for the bases, and Ado, Guo, Cyd, Urd, Thd, Ino, and Xao for their ribosyl nucleosides—with d for deoxy as required—should be used.

* For further examples of this system of abbreviation see, for instance, Heppel, Ortiz, and Ochoa, *J. Biol. Chem.* **229**, 679, 695 (1957), and especially Gilham and Khorana, *J. Am. Chem. Soc.*, **80**, 6212 (1958).

UNITS OF MEASUREMENT

Units of Mass

kilogram	kg
gram	g
milligram	mg
microgram	μg (*not* γ)
millimole	mmole (*not* mM)
micromole	μmole (*not* μM)

Units of Concentration

molar (mole/liter)	M
millimolar (mmole/liter)	mM (in preference to 10^{-3} M)
micromolar (μmole/liter)	μM (in preference to 10^{-6} M)

Units of Length, Area, Volume, etc.

meter	m
centimeter	cm
millimicron	mμ
Angstrom (10^{-8} cm)	A
square centimeter	cm^2
cubic centimeter	cc, or cm^3
milliliter	ml
microliter	μl (*not* λ)
sedimentation coefficient	*s*
sedimentation coefficient in water at 20°, extrapolated to zero concentration	$s^0_{20,w}$
Svedberg unit of sedimentation coefficient (10^{-13} sec)	S
diffusion coefficient (usually given in cm^2/sec)	*D*

Note that, in most instances, liter is not to be abbreviated. Use l, if necessary in tabular matter.

Terms Used in Reporting Spectrophotometric Data—Because there are several ways of reporting spectrophotometric data and some conventions are not generally understood, it is essential for an author to indicate the relation between the symbols used. It is recommended that Beer's law be stated with one of the following sets of symbols.

$$A = \text{OD} = -\log_{10} \text{T} = a_M \text{Cb} = \epsilon \text{Cb} = a_s \text{cb}$$

In these equations *A* is absorbancy (preferred), OD is optical density, T is transmittancy (not transmittance, as for a plate of glass), C is the concentration of the absorbing substance in moles per liter, c is its concentration in other units (which *must be specified*), a_s is the absorbancy index, a_M is the molar absorbancy index

(identical with ϵ, the molar extinction coefficient), and b is length of the optical path in cm. If Beer's law is not applicable to a particular substance in solution, this should be explicitly stated; even in such cases the substance may be characterized by reporting the absorbancy at a specified concentration. If units of C and b are expressed as above, the value of ϵ(or a_M) has the dimensions: liter mole^{-1} cm^{-1}, or more briefly M^{-1} cm^{-1} (*not* cm^2 mole^{-1}).

When a substance is characterized by a molar absorbancy index by use of radiant energy which is not confined strictly (as in a line spectrum) to the wave length or frequency specified, the exact value of this index will be somewhat ambiguous unless the so-called spectral interval isolated is also reported.

See, for instance, K. S. Gibson, *Spectrophotometry (200 to 1,000 millimicrons)* U. S. Department of Commerce, National Bureau of Standards, Circular 484, issued September 15 (1949), U. S. Gov't Printing Office, Washington, D. C.; also, W. M. Clark, *Topics in Physical Chemistry*, Second Edition, pp. 646–657, The Williams & Wilkins Co., Baltimore, 1952.

Equilibrium and Velocity Constants

Dissociation constants, association constants, and Michaelis constants should ordinarily be written in terms of concentrations in moles per liter; for instance, for the reaction $Mg^{++} + ATP^{4-} \rightleftharpoons MgATP^{2-}$, the association constant is: $K = (MgATP^{2-})/(Mg^{++})(ATP^{4-})$; (in units of M^{-1}).

If other units of concentration are employed, they should be clearly indicated at the point where the equilibrium constant is defined, and where its value is given.

Values of velocity constants should be similarly specified, first order velocity constants being generally given in sec^{-1} (other units of time may be used on occasion, but in any case the time unit should be specified). Second order velocity constants are ordinarily given in M^{-1} sec^{-1}.

The term milligram per cent (mg%) should not be used. Weight concentrations should be given as g per ml, g per 100 ml, g per liter, etc.

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Riboflavin	0.50 micrograms per gram
Niacin	0.30 micrograms per gram
Pyridoxine HCl	0.65 micrograms per gram
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